Framework for the Data-Driven Geographical Expansion of Rapid Ecological Assessment Methods

by Jacob F. Berkowitz, Chris V. Noble, and Zachary M. Wilson

PURPOSE: The current study outlines guidance for expanding the geographic extent of existing wetland and stream rapid ecological assessment methods beyond the currently identified area of application. Geographical expansion requires data collection and analysis to ensure technically sound, defensible, and transparent application of ecological assessments used within the Regulatory process. A case study approach is utilized describing the geographical expansion of one assessment method. The document is intended to complement information found in the “Technical Standard for the Development, Evaluation, and Improvement of Rapid Ecological Assessment Methods” and the “Hydrogeomorphic (HGM) Approach to Assessing Wetland Function: Guidelines for Developing Guidebooks (v2.0)” (Smith et al. 2013; Berkowitz In Press).

INTRODUCTION: Wetlands and stream ecosystems support a number of well established biological, chemical, and hydrologic conditions and functions linked to ecosystem services that prove beneficial to society (Novitiski et al. 1996; Smith et al. 1995). Section 404 of the Federal Water Pollution Control Act of 1972 and other federal regulations require the determination of baseline information, mitigation requirements, alternative evaluation, and ecological monitoring; all of which benefit from the consistent application of accurate and defensible ecosystem assessment (ASTM 1998; USC 2011; Carletti et al. 2004; USACE and USEPA 2008). As a result, a variety of ecosystem assessment strategies exist with the goal of improving natural resource management and recent trends in evaluation focus on rapid ecological assessment methods (RAMs) (Stein et al. 2009; 2009b; Wardrop et al. 2007; Figure 1).

Dozens of RAMs have been developed over the years to assess wetlands and streams (Fennessy et al. 2007). A subset of these methods was designed for application in any wetland or stream across the nation (e.g., Proper Functioning Condition; Prichard et al. 1999). However, most RAMs underwent development for application within a limited and specific geographical region. Applicable geographical regions are defined by 1) political boundaries (e.g., Minnesota Routine Assessment Methodology for Evaluating Wetland Functions; MN BWSR 2006), 2) Ecoregions, Land Resource Regions, or Major Land Resource Areas (MLRAs) differentiating between landscapes based upon climate, geologic features, soils, biota, or other features (e.g., Hydrogeomophic Approach; Smith et al. 2013; USDA 2006), 3) areas subject to a particular impact (e.g., surface mining; Noble et al. 2010), or 4) areas containing a particular ecosystem (e.g., prairie potholes; Gilbert et al. 2006). In some cases the applicable extent of RAMs remain limited due to funding constraints for method development and implementation. In other instances, RAMs undergo development to address the needs of a particular state, tribal authority, or local organization (City of Homer, 2006). However, most RAMs are designed to apply within a particular geographical region because limiting the geographic region addressed by a RAM improves accuracy and efficiency by accounting for regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors effecting ecological conditions and functions (National Research Council 1995; Wakeley 2002).

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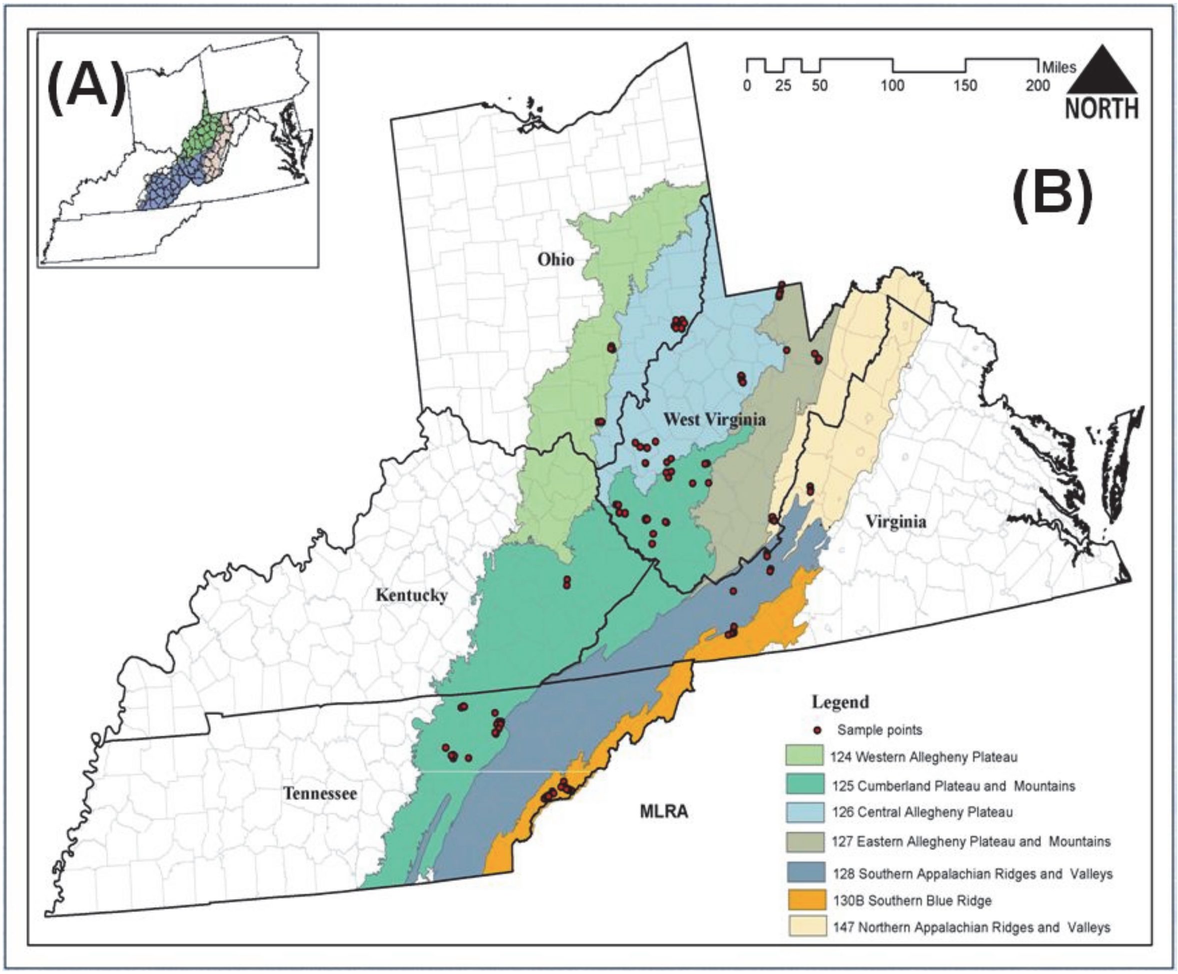

Figure 1. (A) Original area addressed in the RAM. (B) Expanded geographical area. Note that sampling occurred within specific MLRAs, providing a framework for expanding the RAM across areas exhibiting distinct climate, geology, soils, and biological resources. This approach is readily transferrable to alternate mapping schemes including EPA Level III Ecoregions (Omernik, 1987) and U.S. Forest Service ecological sections (McNab et al. 2007).

Recent interest has focused on the potential application of RAMs developed within a specific geographical region into surrounding areas (Stein et al. 2009). Geographical expansion of existing methods benefits method developers and funding entities by significantly decreasing costs associated with developing a RAM from initiation to implementation (Smith et al. 2013). Additionally, end users benefit from ecological expansion, as users often exhibit familiarity with the data collection and analysis techniques utilized in existing methods. Further, the geographical expansion of RAMs promotes predictable, consistent, and transparent natural resource management decisions across large regions of the nation.

In 2010, the U.S. Army Corps of Engineers published a rapid ecological assessment for the evaluation of high-gradient ephemeral and intermittent streams in western West Virginia and eastern Kentucky (WVKY Method; Noble et al. 2010). Data collected and analyzed from over 90 study sites formed the basis of the WVKY Method, which required several years. The original geographical extent of the WVKY Method encompassed portions of three Major Land Resource Areas (MLRAs;

Figure 1A). Following implementation of the WVKY Method, USACE Headquarters, Regulatory staff, and other end-user groups requested the expansion of the WVKY Method into adjacent areas incorporating the majority of the Appalachian region (Figure 1B). The expansion of any assessment into regions outside of the initial development area requires the collection of similar data from the new geographic area (Berkowitz, in press). The data must be analyzed to determine if significant differences exist between data collected as part of initial RAM development and the area of intended expansion. If differences exist, the RAM must undergo revision and verification to ensure that the RAM provides technically sound, defensible outcomes across in the expanded area. The following sections outline a framework and provide guidance on the steps involved in the geographical expansion of RAMs utilizing the WVKY Method expansion as a demonstration case study.

STEPS IN GEOGRAPHICAL RAM EXPANSION:

1. *Examine the geographical range of the existing RAM* - The original WVKY Method applied to Major Land Resource Areas (MLRAs) 125, 126, and 147 (Figure 1A; NRCS 2006).

2. *Determine the desired area of application* –Project objectives included expansion of the WVKY Method across the Appalachian mountain region encompassing MLRAs 124, 125, 126, 127, 128, 147, and 130B including portions of TN, KY, WV, OH, and VA (Figure 1B).

3. *Collect data in designated regions* – The amount of data required to effectively expand an existing RAM into additional areas depends on the size of the expansion region, the degree of difference in climate, geology, soils, and biological resources between the original application area and the expansion region, and the variability of conditions and impacts observed. However, less data is required than needed to develop a RAM from inception through implementation; this can significantly reduce the time and cost associated with assessment development. A power analysis can help determine the number of study sites required (Steyer et al. 2003). As a rule of thumb, at least 15 to 30 sites should be examined across the expansion area (Smith et al. 2013). For the expansion of the WV/KY Method, data collection occurred at 86 sample locations spread across the region of interest. Sample locations were targeted to incorporate data from each MLRA within the desired expansion area. Additionally, data collection was designed to capture the range of ecological impacts that occur within the region including undisturbed forested watersheds, urban areas, agricultural areas, and watersheds containing ongoing and historical mining activities. Not all impact types occurred within each expansion MLRA. At each sampling location, the ten variables associated with the WVKY Method were collected according to the written protocols described by Noble et al. (2010) (Table 1).

4. *Determine if significant differences occur between the original RAM dataset and expansion data using visual examination and statistic*s – Following data collection, results were examined visually using scatter plots and bar graphs to evaluate differences between data collected in each MLRA including data contained in the original dataset (Figure 2). Statistical tests indicated normality and homogeneity of variance of data. Analysis of variance (ANOVA) was utilized to determine if statistically significant differences existed among the expansion MRLAs and the original WVKY Method dataset. ANOVA results identified no significant differences, the lack of statistical differences indicates that the assessment method can be applied within the expanded area without revision or modification (Table 1). Additionally, an

Table 1. Results of ANOVA and ANCOVA (α = 0.05). Lack of statistical differences between MLRAs demonstrates that the RAM can be expanded without making adjustments.

Variable	ANOVA	ANCOVA
1. Canopy cover	F(6, 37)=1.21, p=0.33	F(6, 24)=1.65, p=0.18
2. Embeddedness	F(6, 37)=0.89, p=0.09	F(6, 24)=0.88, p=0.57
3. Substrate size	F(6, 37)=0.76, p=0.14	F(6, 24)=1.31, p=0.92
4. Erosion	F(6, 37)=1.78, p=0.90	F(6, 24)=1.22, p=0.33
5. Large Wood	F(6, 37)=0.95, p=0.48	F(6, 24)=1.95, p=0.11
6. Tree diameter	F(6, 37)=2.10, p=0.08	F(6, 24)=0.95, p=0.46
7. Snag density	F(6, 37)=1.01, p=0.44	F(6, 24)=0.82, p=0.72
8. Species richness	F(6, 37)=0.83, p=0.55	F(6, 24)=2.00, p=0.11
9. Detritus cover	F(6, 37)=1.84, p=0.12	F(6, 24)=3.10, p=0.19
10. Land use	F(6, 37)=2.46, p=0.06	F(6, 24)=2.50, p=0.13

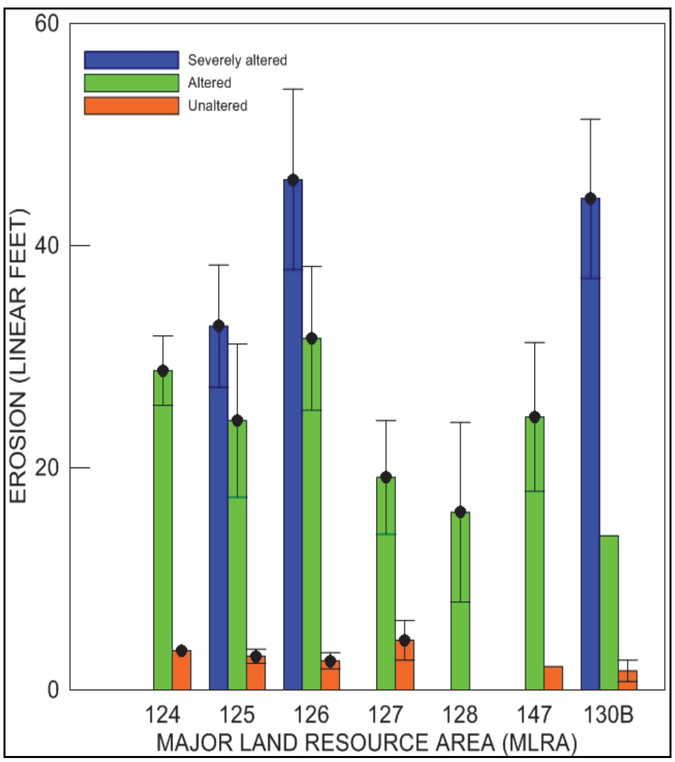

Figure 2. Visual representation of one RAM variable examining erosion at study sites. Results indicate that no significant differences were observed across MLRAs within unaltered, altered, and severely altered locations, verifying RAM expansion. Error bars equal 1 standard deviation.

analysis of covariance (ANCOVA) was conducted to investigate potential impacts of site alteration on the expansion dataset. Each sample location was grouped into one of three alteration categories (unaltered, altered, and severely altered) based upon the presence of observable site condition. Unaltered sites consisted of intact forested watersheds exhibiting limited erosion and sedimentation. Altered streams consisted of areas displaying mixed watershed usage (e.g., forested areas interspersed with urban development) and limited signs of instream impacts. Severely altered locations included areas exposed to surface mining activities and containing constructed or engineered stream channels. Once assigned, alteration categories were applied as the covariant. Again, no statistically significant differences were detected, indicating that the assessment method can be applied within the expanded area without modification.

5. *Determine if additional considerations are required* – In additional to visual examination and application of statistical tests performed on RAM variables, expansion studies must consider other factors with potential implications in the expanded region. For example, does the expansion area contain additional impact types? Invasive species? Species compositions? Does the RAM function as intended in the expanded region (Smith et al. 2013)? No additional impact types or invasive species were reported during the current expansion project. However, a number of tree species were encountered within 130B that do not occur within the original area addresses by the WVKY Method. As a result, the expanded WVKY Method will be revised to incorporate the additional species. Throughout the collection and analysis of expansion data, the WVKY Method operated as intended with sample areas exhibiting intact forested watersheds receiving high RAM scores and sites containing a gradient of alterations receiving appropriately lower RAM scores.

6. *Draft an expanded version of the RAM* – The WVKY Method is currently undergoing revisions to reflect the outcomes of the expansion study. The revised document will include updated maps of the expanded region of application and additional tree species reported during expansion data collection.

7. *Submit the expanded RAM for stakeholder field testing and peer review, revise and publish the RAM* – Following completion of the draft, the expanded RAM will undergo field testing by end-users across the expanded region. Additionally peer review will be conducted. Based on comments and suggestions from field testing groups and peer reviewers the RAM may undergo further revision prior to publication and implementation across the expanded area.

SUMMARY: Many RAMs designed for application within a specific geographic area are presently being utilized in other regions with limited or no supporting data. The current study provides a framework and guidance for data collection and analysis supporting the data-driven expansion of RAMs across wider areas. The current study detected no significant differences between the original dataset and the expansion data, indicating that the WVKY Method can be applied across the examined region without modification. If significant differences had been detected, the specific RAM variables identified would have undergone revision to reflect the conditions encountered within the expanded area. The data-driven expansion of existing RAMs into larger geographic areas provides a cost effective and transparent approach for providing the tools needed for making informed and scientifically supported decisions regarding wetland and stream resources.

POINT OF CONTACT:

Chris V. Noble, 601-634-3482, Chris.V.Noble@usace.army.mil

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